Complex Changes: Visualizing Teacher's Accurate Understanding and Misconceptions Regarding Scientific Inquiry and Nature of Science

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Abstract

This study seeks to describe and explain patterns of change of in-service teachers' accurate understanding and misconceptions regarding scientific inquiry (SI) and nature of science (NOS) after participating in professional development (PD) funded by the National Science Foundation Mathematics Science Partnership program. This study reported findings from teachers' responses to a Likert-type scale questionnaire prior to beginning professional development and after one, two, three, and four years of participation. Instead of reverse coding misconception items and including them in the same factors, teachers' pre- and post-scores for accurate understandings (y-axis) and naïve understandings (x-axis) were plotted to determine the relationship between accurate and naïve conceptions and to represent change in teachers' understandings over time. This study provides a visually direct way to examine teachers' progression in understanding of SI and NOS and to identify and locate their transitional stages. Measurement methods that account for changes in both accurate and naïve understandings allow researchers to study how teachers' trajectories in developing accurate understanding of SI and NOS influence their teaching practices and student learning. Findings from this study also are fundamental to understanding how teachers' learning of accurate conceptions of SI and NOS is impacted by PD programs so that teacher professional development can be improved.

Subject/Problem

Research described in this paper seeks to understand the change of in-service teachers' accurate understanding and misconceptions regarding scientific inquiry (SI) and nature of science (NOS) after participating a professional development (PD) program funded by a National Science Foundation (NSF) Mathematics Science Partnership (MSP) project. This ongoing study is part of the evaluation of this 5-year project whose goal is to improve student learning in standard areas of science by enhancing teachers' science inquiry knowledge and skills and enabling the implementation of interdisciplinary inquiry-based science teaching across all content standards.

Design and Procedure

Since Summer 2012, science teachers from 12 middle and high schools in a large urban school district with high needs and a high poverty rate have participated in this PD program. A teacher questionnaire has been administered to participant teachers every summer. To date, 125 teachers have responded to the questionnaire at least once. This study used a sample of teachers who began participating in the PD program in Summer 2012, Summer 2013, or Summer 2014 and

responded to the questionnaire at least twice between Summer 2012 and Summer 2016. Teacher responses were analyzed to measure change in their understanding of SI and NOS following one, two, three, and four years of PD participation.

The teacher questionnaire was developed with permission from instruments previously used in NSF and USDOE MSP projects and in DRK12 projects. The SI and NOS subscales on this instrument each contained 20 items on a 5-point Likert-type scale with responses coded as *strongly disagree* (-2) to *strongly agree* (2). Items on these two subscales were modified with permission from existing validated instruments[1]. The SI and NOS subscales each contained 13 items measuring accurate understanding and 7 items measuring naïve understanding.

"Accurate understanding" scores of SI or NOS were calculated as the sum of 13 accurate understanding items ranging from -26 to 26 with -26 indicating the strongest disagreement and 26 indicating the strongest agreement with all statements representing accurate understanding of SI or NOS. "Naive understanding" scores of SI or NOS were the sum of 7 misconception items ranging from -14 to 14 with -14 indicating the strongest disagreement and 14 indicating the strongest agreement with all statements representing naïve understanding of SI or NOS.

Findings and Analyses

This paper is the third in a series of papers presented at NARST conferences. The authors previously have reported on the validity and reliability of questionnaire subscales to measure teachers' understanding of SI and NOS and subsequently developed a two-dimensional representation to understand change in teachers' accurate understanding and misconceptions of SI and NOS over time. At the 2015 NARST conference, researchers reported on difficulty establishing reliable factors for the SI and NOS instrument subscales. Measurement issues emerged when teachers' accurate understanding and misconceptions of SI and NOS co-existed and were measured on the same subscale. Data collected each year have provided evidence that teachers possessed both good understandings and misconceptions regarding SI and NOS at the same time, both before and after participating in professional development. Exploratory factor analyses established three factors for each of the subscales. Even though all factors were conceptually valid and stable, factors including both accurate understanding and misconception items showed relatively low internal consistency reliabilities and had misfit items using Rasch analyses; while factors with only accurate understanding or misconceptions showed high internal consistency reliabilities and no misfit items. Researchers determined that reverse coding misconception items to calculate factor scores to represent the latent construct was inappropriate.

At the 2016 NARST conference, we developed and presented a visually direct way to assess teachers' change in understanding of SI and NOS before and after participating in PD, responding to the need to identify an appropriate and descriptive way to measure the coexistence of accurate and naïve understanding of SI and NOS. Instead of reverse coding misconception items and including them in the same factors, we used a two-dimensional visualization to

[1] Lederman (2006); National Research Council (2000); Liang et al. (2006); and National Science Teachers Association (2000).

concurrently represent teachers' accurate and naïve understandings. Teachers' responses to the questionnaire prior to beginning PD were compared to their responses after three years of PD involvement. Teachers' pre- and post-scores for accurate understandings (y-axis) and naïve understandings (x-axis) were plotted to determine the relationship between accurate and naïve conceptions and the change in teachers' understandings over time. As shown in Figure 1, plotting accurate and naïve understandings created four domains that represent the intersection of teachers' views. Preliminary findings indicated that some teachers demonstrated greater agreement with accurate conceptions and less agreement with naïve conceptions of SI and NOS, while others either showed greater agreement with both accurate and naïve conceptions, or less agreement with both over time.

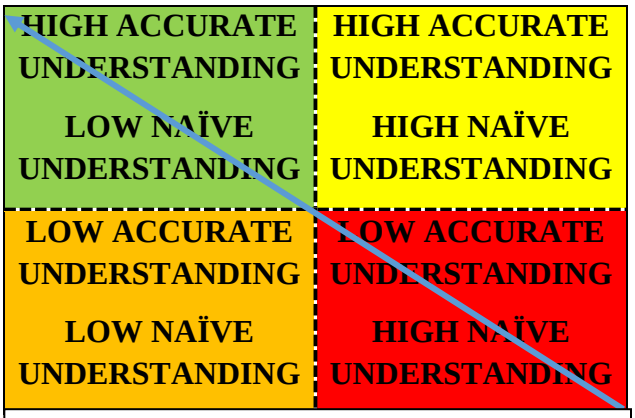

Figure 1. Domains of teachers' understandings of Nature of Science and Science Inquiry.

This year, we used additional data collected between Summer 2012 and Summer 2016 to further explore patterns of change in teachers' accurate and naïve understanding of SI and NOS across five years of PD participation. As shown in Figures 2 and 3, we plotted teachers' changes in understanding of SI and NOS for one, two, three, and four years of PD participation, separately. Teachers' "accurate understanding" scores ranged from 0 to 26 for SI and from -2 to 26 for NOS, indicating that teachers held reasonably accurate understandings of SI and NOS even before they participated in PD. However, the ranges of "naïve understanding" scores were -14 to 8 for SI and -14 to 9 for NOS, which indicates that some teachers demonstrated a fair amont of misconceptions prior to and during PD participation.

Several noteworthy patterns are seen in Figures 2 and 3. First, there was a wider range in teachers' SI and NOS scores before and one year after PD participation than there was in later years. Following teachers' second and third years of PD participation, their SI and NOS scores clustered more toward the middle. Second, the magnitude of change in teacher's understanding of SI following one year of PD participation was generally greater than were changes following subsequent years of PD participation, regardless of the direction of change. However, large changes in teachers' understanding of NOS continued to be found at later stages of PD participation. Third, two-dimensional changes (i.e., diagonal lines) in SI and NOS scores were more typical than were one-dimensional changes (i.e., horizontal or vertical lines) regardless of whether changes were in the desired or undesirable direction. Fourth, teachers' understanding of SI and NOS generally improved more during their first year of PD participation (i.e., gained accurate and lost naïve understanding) than during their second and third years of PD participation, but data suggest that teachers' naïve understandings of SI and NOS increased

between their third and fourth years of PD. Fifth, while there are patterns in teachers' aggregate development of SI and NOS understanding, each individual teacher's trajectory of change in SI and NOS understandings is unique. For example, some teachers demonstrated positive changes in earlier years yet regressed in later years (e.g., T8, T30), while others' understandings developed more slowly but ultimately resulted in greater positive change (e.g., T56). Also, some teachers alternated between positive and negative changes from year to year and demonstrated little change in understandings after four years of PD participation (e.g., T50).

Contribution and Significance

The purpose of this ongoing study is to explore an alternative method to assess patterns of changes in teachers' understanding of SI and NOS using Likert-type scale measurements. Findings of this study are congruent with recent literature, including, most notably Lederman and Lederman, who have explored how teachers' views of NOS and understandings of SI change from naïve to informed, and have identified a "transitional or mixed" stage where teachers demonstrate some accurate understandings while not relinquishing naïve ones (Lederman et al, 2014). Plotting accurate conception scores and naïve conception scores provides a visually direct way to study teachers' progression in understanding and to identify and locate their transitional stages. Measurement methods that account for changes in accurate and naïve understandings allow researchers to study how teachers' trajectories in developing accurate understanding of SI and NOS influence their teaching practices and student learning. Findings from this study can help close gaps in understanding of teachers' learning of accurate conceptions of SI and NOS from PD programs so that teacher professional development can be improved.

Initial results of this line of inquiry provided tentative evidence that teachers possessed both accurate understandings and misconceptions regarding SI and NOS at the same time, and further suggest that change of teachers' belief systems is a complex and long-term process. The two-dimensional visualization system developed by these researchers provides valuable information to study patterns of change of teacher belief systems and provides a framework for studying the impact of these changes on teachers' instructional practices. Next, researchers will examine the relationships among teachers' understanding of NOS and SI and collect more data regarding internal (teacher) and external variables (PD features) to determine how particular PD features are related to teachers' SI and NOS acquisition.

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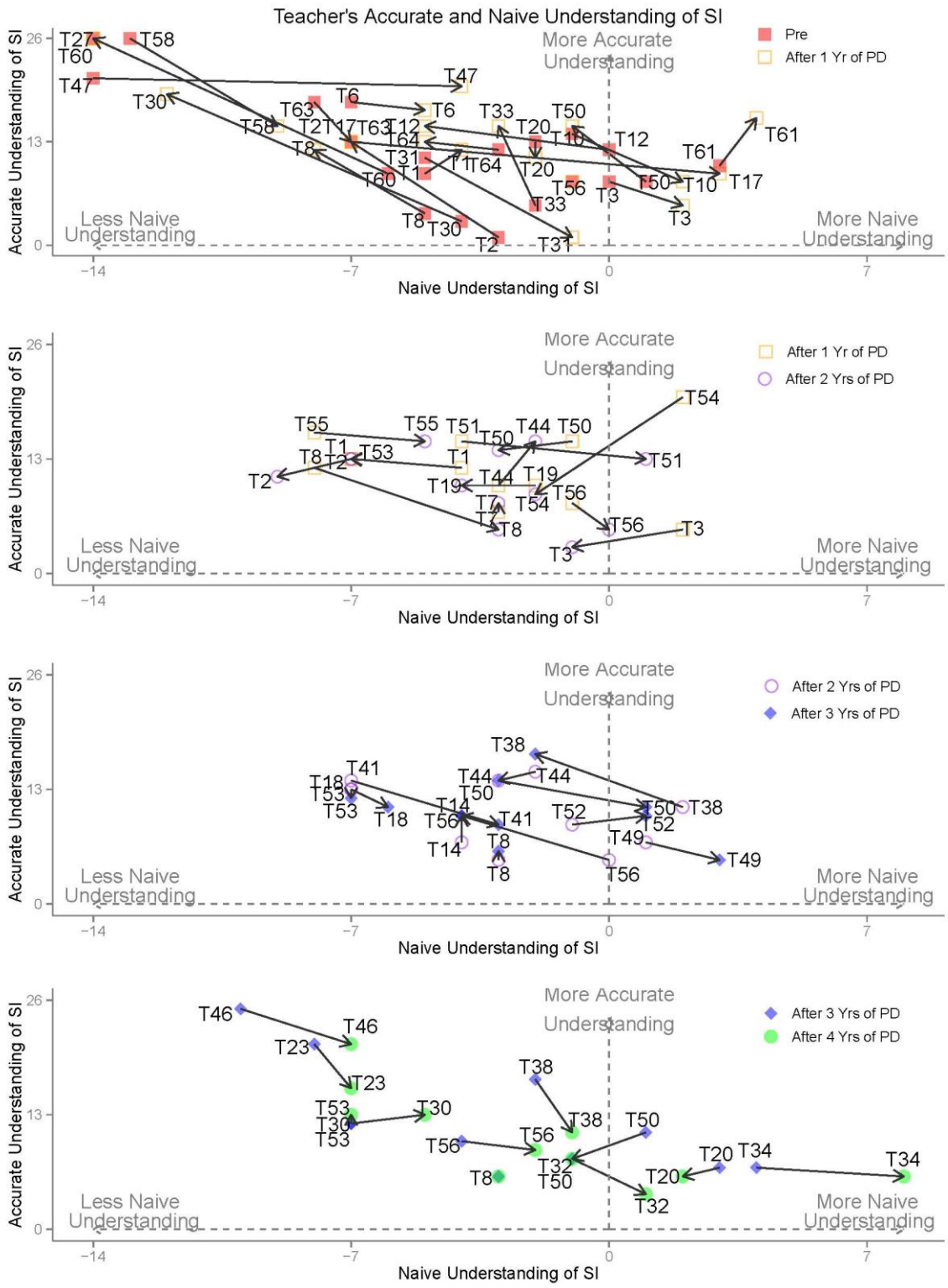

Figure 2. Change in teachers' understandings of scientific inquiry.

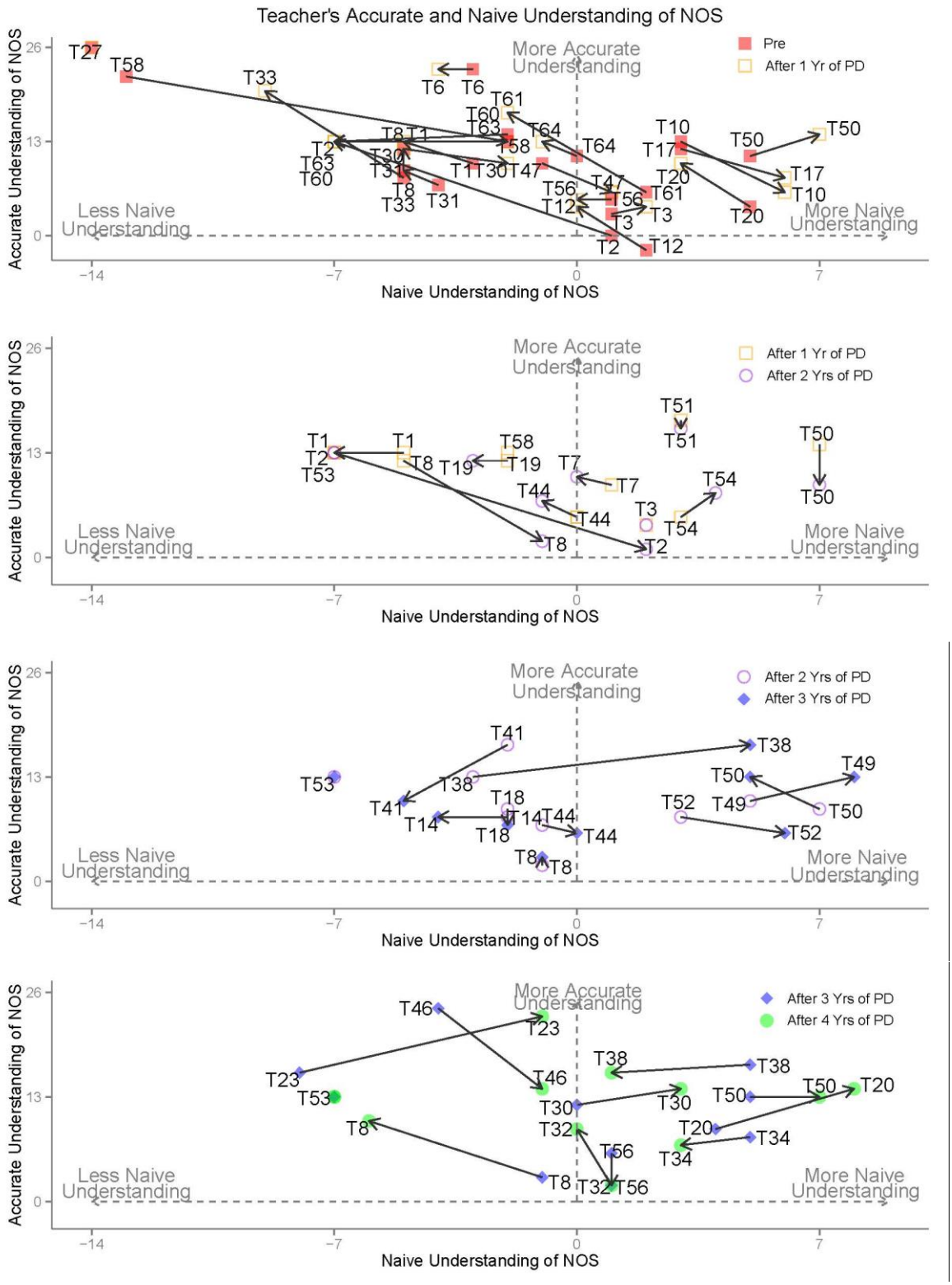

Figure 3. Change in teachers' understandings of NOS.